

A comparative study to the 2011/2013 water quality assessments in the Pasquotank Watershed in Northeastern North Carolina with a sea level rise component

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Abstract- The Pasquotank River Watershed is found in Northeast North Carolina beginning in the Great Dismal Swamp at the Virginia/North Carolina border and flows into the Albemarle Sound. The watershed provides a transition between spawning grounds and the waters of the Albemarle Sound. The sound serves as a nursery area for many fish species and is home to numerous sport and commercial species. Due to indications of rising global temperature and the monitoring of melting ice sheets, these coastal watersheds could be a leading indicator of rising sea levels as their chemical compositions changes. The effects of sea-level rise were also taken into consideration for future monitoring.

The 2014 Research Experience for Undergraduates Pasquotank River Watershed Team completed two sets of tests of five tributaries and the river itself. These test points were derived from the 2011 and 2013 Watershed Team research projects with the addition of four points created to sample further downstream in the Pasquotank River itself. Results were compared with previous readings utilizing a Water Quality Index (WQI). The streams tested were the Pasquotank River, Newbegun Creek, Knobbs Creek, Areneuse Creek, Mill Dam Creek, and Sawyers Creek. These streams, along with the river, cover a large portion of the watershed and provide a wide area of study for the watershed.

Tests performed in the laboratory on this year's samples included pH, salinity, total dissolved solids, and conductivity. Air/water temperature, dissolved oxygen, wind speed/direction, and turbidity/clarity measurements were taken in the field. The results collected were placed online and displayed in correlation to their position utilizing Google Maps. The data were then compared to the 2011 and 2013 project results and examined for any variations or similarities.

It was found that the water quality for some water sources remained in their respective ranges from the past years. The others, such as Knobbs Creek, varied from the previous years.

Newbegun Creek, with a water quality index of 59, stayed within the two previous teams' WQI of 50 (2011) and 66 (2013). Mill Dam Creek had a very slight increase in water quality from the previous teams' readings 47 (2013) and 48 (2011) but still managed to acquire a bad reading of 49. Areneuse Creek increased from 49 (2011) and 47 (2013) to reach a medium water quality of 57. The Pasquotank River, ranking as the lowest, has dropped significantly from 64 (2011) to 44 (2013) and continued to be lower in 2014 standing at 41 for its WQI. Sawyers Creek remained consistent between 54 (2011) and 50 (2013) at a low medium range with this year's water quality being 51. Knobbs Creek WQI, having the highest water quality reading, increased from the two past readings of 52 (2011) and 50 (2013) with a WQI of 63.

Keywords: Water quality, Pasquotank, watershed, dissolved oxygen, pH, salt, conductivity, clarity, turbidity, sea level rise, global warming.

I. INTRODUCTION

A. Overview

A watershed is a group of smaller bodies of water that flow into a larger body of water. The Targeted Local Watershed (TLW) for this year's research was the Pasquotank Watershed, which included the Pasquotank River and several of its tributaries. The contributing waterways tested in this research were Knobbs Creek, Sawyers Creek, Areneuse Creek, Mill Dam Creek, and Newbegun Creek.

There are three types of watersheds: continental divides, major drainage divides, and minor drainage divides. The Pasquotank is a minor drainage because it divides, but eventually rejoins. [1]. Watersheds maintain many life forms. According to the Environmental Protection Agency (EPA), more than \$450 billion in foods, fiber, manufactured goods

and tourism depend on clean, healthy watersheds. That is why proper watershed protection is necessary. [2].

The 2014 Pasquotank Water Quality Team gathered the following data in order to evaluate the quality of the water: dissolved oxygen, turbidity, clarity, total dissolved solids (TDS), salinity, pH, and conductivity. Other items such as wind speed/direction, air/water temperature, latitude/longitude, and date/time were also recorded as factors that could influence the final analysis. This data was compared to the 2011 and 2013 summer research projects, which targeted the same waterways.

An added component to this year's research was a focus on salinity as a result of sea level rise. As sea level rise occurs, coastal estuaries and ground water supplies are inundated with higher levels of salt affecting local plant and animal populations as well as residents living along the coast. Reduction in coastal forests has been documented in other areas of the United States. A drop in the number of species has also been recorded as their nesting and feeding areas undergo change. Testing points added in the lower Pasquotank River out to the mouth of the Newbegun Creek will allow for an increase monitoring of salinity levels in the Pasquotank Watershed. [29]

B. Dissolved Oxygen

Dissolved Oxygen is a key factor in marine life. Dissolved oxygen is a relative measure of the amount of oxygen that is dissolved or carried in a given medium. The volume and velocity of water flowing, the climate, the water temperature, and the types of organisms living within the water are factors to the dissolved oxygen. [3] During the summer, the water temperature has a high influence on dissolved oxygen because a high water temperature equals a lower reading in dissolved oxygen [4]. Dissolved oxygen usually is rather higher in shallow areas and decreases in deeper waters. The width of the waterway being tested also influences the readings as wide waterways are disturbed more by winds passing over them than narrow waterways.

The standard unit of measurement used for the tests completed in the laboratory was milligrams per liter (mg/L). This information was converted into a unit of "percent saturation" (%sat) in order to use the readings in the Water Quality Index calculations.

C. Turbidity

Turbidity refers to the optical property that causes light to be scattered and absorbed by particles and molecules. [5] Higher turbidity increases water temperatures because suspended particles,[6] which can promote regrowth of microorganisms in the distribution system, absorb the light converting it into heat. It is measured in inches and converted into [7] Streams with high turbidity absorb more heat, and also reduce the amount of light penetrating the water, which reduces photosynthesis and the production of Dissolved Oxygen (DO). [6]

D. Clarity

Water clarity is a measure of the amount of sunlight that can penetrate through the water. [8] Water clarity is affected by water color. [9] Two types of color of water are apparent color and true color. Apparent color is water sample that has not had substances filtered out of the water, and true color is water sample that has had all the substances filtered out of the water. [10]

E. Total Dissolved Solids (TDS)

Total Dissolved Solids are the total amount of mobile charged ions. These mobile charged ions include minerals, salts, and metals that are dissolved in a given volume of water. TDS is related to the purity of water. A high level of TDS is an indicator that the water has toxic ions which is often caused by the presence of potassium. [11]

F. Salinity

Salinity is the amount of dissolved salt in a body of water. Salinity determines what types of living things live in that specific environment. The unit of measurement for salinity is parts per millions (ppm). The higher the salinity reading, the lower the dissolved oxygen reading will be. [12]. Salinity can also be an indicator of sea level rise as ocean waters encroach on brackish and coastal watersheds. The sun can affect salinity more in the summer than the winter because higher temperatures increase levels of evaporation.

G. Conductivity

Conductivity is the measure of water's capability to pass electrical flow. It is affected by negative charged ions such as chloride and nitrates or positive charged ions like calcium and sodium. The more ions present, the higher the conductivity will be. Conductivity is also affected by water temperature as both factors will either increase together or decrease simultaneously. Conductivity is measured in Siemens (mho) which is a reciprocal of resistance (ohm). [12].

H. pH

The pH measurement is used to determine if a solution is acidic or basic. The pH readings range from 0 to 14 with acidic levels between 0 and 6.9 units and basic levels between 7.1 and 14. A reading of 7 is considered to be neutral. If either substance is very acidic or very basic, then the substance is reactive as it can cause a serious chemical burn. [13].

II. EQUIPMENT

A. Positions

Latitude and longitude points were taken from the 2011 and 2013 Water Quality Team projects for each waterway to assist in comparing data. All of the longitudes and latitudes were loaded into the Garmin GPSMAP 60CSx, a handheld Global Positioning System (GPS) device, which was loaded the Garmin BaseCamp software. There were four points added to the Pasquotank River with the Garmin BaseCamp software, also. Garmin BaseCamp software is a three-

dimensional application that allows waypoints, tracks and routes to be transferred from one device to another. [14]

B. Research Platforms

A canoe was used to travel through each of the small, narrow creeks. The LH Viking, a 22-foot Sea Pro Model 210 fiberglass boat, was used to travel through the Pasquotank River, Newbegun Creek, and the first trip through Areneuse Creek. During testing of the Newbegun Creek, the kayak was used to travel under a bridge to obtain the remaining test points of that waterway.

C. Water Temperature

The thermometer is a tool that measures water temperature in degrees Fahrenheit and Celsius. The protective plastic case protects the glass thermometer from breakage. The thermometer was lowered to a depth of three feet for one minute to allow the temperature to settle and then raised to the surface to view the temperature of the water.[15]

D. Wind Speed/Air Temperature

The Skymate Wind Meter is an anemometer that was used to measure wind speed. The test equipment also has a digital temperature gauge to measure the air temperature. The wind speed was measured in knots, where one knot is one nautical mile per hour, which is 6076 feet per hour. [16] The temperature was measured in degrees Celsius (°C) for this project.

When measuring the wind speed hold the meter away from the body and in the air. Give the meter time to stabilize and record the wind speed. The reading will rarely completely settle due to fluctuations in wind speed. When reading the temperature, the same steps apply. After obtaining the readings from the Skymate Wind Meter, it should be closed to protect the instrument impeller blades.

E. Dissolved Oxygen

The MW600 Dissolved Oxygen Meter is an instrument used to measure dissolved oxygen in waters such as creeks, rivers, and ponds. It is calibrated at two points: 100% saturated air and in a 0% oxygen solution. It has an Automatic Temperature Compensation which will guarantee the highest accuracy. [17]

To operate the Dissolved Oxygen Meter, first make sure the device is on and set to 0.0 milligrams per liter (mg/L). Next, remove the red and black cap, which exposes the probe. Set the probe in the electrolyte for approximately 5 to 10 minutes. Gently tap the sides of the membrane with a pencil to avoid any air bubbles that may form. As the meter starts to calibrate, press and hold the “CAL” button and set the display to 100%. Then, release the CAL key and the LCD will display a value in mg/L of oxygen. [18].

Before testing in bodies of water, remove the plastic cap which exposes the membrane. Set the membrane in the body of water and wait until the meter reading is steady.

F. Turbidity/Clarity

The Secchi disk is a circular plate with two sides, a side divided into quarters and painted black and white and a side that is completely black. The side that is completely black measures the turbidity of the water. The side that is divided into quarterly parts measures the clarity of the water. The plate is able to be detached in order to change the sides to perform the measurements. This plate is attached to a rope that has marked lines that represent the depth of the disk in inches.

The plate was lowered into the water until it could no longer be seen. The point on the rope which was at the water's surface was then used to determine the depth reading. The rope was lowered farther then slowly brought back up until it was visible again, then the reading was taken again. The average of these two readings was then calculated. This procedure was completed for clarity and turbidity.

Clarity is how clear the water is. Turbidity is a measure of the degree of the degree to which the water loses its transparency due to the presence of suspended particles. [19]. With clarity and turbidity, the lower the disk the clearer the water. The secchi disk readings are subjective because of the difference in the tester's vision as well as the weather conditions.

G. Conductivity/ Salinity/ Total Dissolved Solids

The Tracer Pocket Tester is a self-calibrated tester that measures salinity, conductivity, and total dissolved solids (TDS). Conductivity determines the amount of particles in that area of water and is measured in Siemens (mho). Salinity determines the saltiness of the water and is measured in parts per million (ppm). TDS measures all of the dissolved solids in the water and is also measured in parts per million (ppm). This pocket tester has two probes that are protected by an electrode. The probes should not be touched by anything but the water as it can cause an inaccurate reading. [20]

To change between the three modes, press and hold “MODE” until SAL, CON, or TDS appears at the bottom of the screen. SAL is salinity; CON is conductivity, and TDS is total dissolved solids. At the top of the screen, under the curved line, there are also indications that will tell what mode the pocket tester is in. In TDS mode, “ppm” will appear in the top left corner. In CON mode, μS or mS will appear in the middle. In SAL mode, “ppm” will appear in the top left corner and “S” will appear in the middle. When placing the pocket tester into the sample of water, stir it slowly to get rid of any air bubbles that may be on the probe. Allow the pocket tester reading to settle in order to get an accurate measurement for each mode.

H. pH

The Aquarium Testing Unit (pH meter) is an instrument used to measure if a solution is acidic or base. The pH meter's range is from 0.0 (acidic) to 14.0 (base) with 7.0 being neutral. From 0.0 to 6.9, it is an acidic while a base is in the pH range of 7.1 - 14. [21].

To use this device, first calibrate the pH meter to a neutral setting of 7.0 by pouring distilled water into a cup and placing a 7.0 mini-buffer tablet into the water. Stir the water to dissolve the tablet. Set the pH meter in the water, stir for thirty seconds, and then calibrate the meter to 7.0 by using the screwdriver on the calibration potentiometer until it reaches the midpoint of 7.0. The meter is now ready to be used for the water samples acquired. Set the pH meter in other solutions to obtain the specific pH reading.

III. SOFTWARE APPLICATIONS

A. Overview

After recording all the results from the testing, the team used a variety of software packages to make the analysis easier. All of the software contributed in different ways as far as moving from and to destinations and recording data. The following software packages were used during this research: Garmin BaseCamp, Google Maps, Adobe Dreamweaver, Microsoft Excel, and the Water Quality Index Calculator.

B. Google Maps

Google Maps is a three-dimensional software feature that allows people to get an accurate reading on a specific location. This is because of the SkyBox Imaging Satellites that are offered for this feature. [22] This allows for precise turn by turn navigation. Google Maps was used to display the map results from the field work and in-house testing.

C. Dreamweaver

Adobe Dreamweaver CS5 is a software application that can use to create and maintain a website. [23] Adobe Dreamweaver allowed for the use of JavaScript and HTML in order to create visualization pages for the test results. Dreamweaver was also used to create the Water Quality Team's project documentation pages and results.

D. Microsoft Excel

Microsoft Excel is a spreadsheet to organize, manage, calculate, and convert data. [24]

This software was used to put in data in order to assist in analyzing and comparing the data gathered. Microsoft Excel was also used for graphing and charting to assist in identifying trends and comparing data. [25] This project also used Excel for calculations in completing the Water Quality Index and averaging stream data.

E. Water Quality Index Calculator

The Water Quality Index Calculator is an Excel spreadsheet that uses specific calculations to form a water quality index reading. Factors are entered and multiplied by the respectable weight factors to get subtotals. The subtotals are then added together to get the water quality index. If there are less than nine factors entered, the same methods are applied. [26] From zero to fifty, the water quality would be bad. The water quality is normal from the range of fifty to seventy. Seventy to ninety shows a good water quality reading. To achieve an excellent water quality, the water quality index has to read at ninety or higher.

F. Garmin Base Camp

Garmin Base Camp is a mapping application that allows the user to transfer waypoints, tracks, and routes between the computer and the Garmin device. [27] This software assisted with creating and organizing waypoints and routes. A total of seventy-six test points, including four new points being added in the Pasquotank River, were tested this year. Each of these points was visited twice during this research project.

IV. METHODOLOGY

A. Pre-Field Work

Preparing for the fieldwork, the Global Positioning Systems (GPS) devices were loaded with points and routes by using the Garmin BaseCamp software for each waterway. Before each waterway was tested, the Dissolved Oxygen (DO) meter was calibrated using zero solution and distilled water. Once the meter was calibrated, a checklist was completed to ensure that all test equipment was gathered and fresh batteries were installed. Duplicate test equipment was taken on each trip to ensure that data would be captured.

B. Field Work

The canoe or boat was launched into the water and was loaded with the gear needed such as paddles, communication devices, test equipment, and data sheets. The test equipment was secured to the boat in case of an accident.

At each test point, several pieces of data were recorded. The time was noted as a reference for samples being taken as several test results could vary during the day. Once the time was taken, wind speed, wind direction, and air temperature were obtained. The water temperature and water sample were acquired utilizing the thermometer and bottle attached to a pole allowing them to be obtained at a consistent depth of three feet. The clarity and turbidity were acquired using the Secchi disk and the amount of dissolved oxygen in the water was obtained by using the DO meter.

C. Post-Field Work

Once all the data was collected, in-house tests were performed to obtain the pH, conductivity, salinity and the total dissolved solids information. The pH meter was calibrated using distilled water and a pH tablet. The water samples that were taken from the field work were poured into small styrofoam cups for testing. The pH meter was placed into the sample and the pH readings were recorded. This was also done for the Pocket Tester which was used to test salinity, conductivity, and total dissolved solids.

D. Data Entry

When all the testing was completed, the data readings were transferred to a Microsoft Excel spreadsheet. Microsoft Excel was used to calculate averages and for visual comparison utilizing graphs. This spreadsheet contained data in the following columns: name of the waterway, point in the waterway, time, date, pH, DO, corrected DO, water temperature, air temperature, clarity, turbidity, total dissolved solids, conductivity, salinity, wind speed, and wind direction.

Columns and rows were also used to average the data. The data in the spreadsheet was merged with HTML and JavaScript to be used in Google Maps to be displayed in the web browser.

V. ANALYSIS

A. Water Quality Index

The overall water quality index (WQI) for all of the waterways that were tested remained constant. Individually, some have either fallen, some have risen, and the others remain in a range set by the past teams.

Newbegun Creek's water quality fell between the two water qualities recorded by the 2011 team and the 2013 team with a medium WQI. Mill Dam Creek's water quality has risen higher than both teams' readings but still has a bad WQI. Areneuse Creek's water quality is greater than the previous years and advanced to have a medium WQI. The Pasquotank River's water quality is lower than the 2013 and 2011 teams' readings and has the lowest reading for the 2014

| 2014 Water Source | pH | D.O. (mg/L) | Clarity (in) | Turbidity (in) | TDS (ppm) | Salinity (ppm) | Conductivity (microsiemens) | H2O Temp (C°) | Air Temp (C°) |
|-------------------|-----|-------------|--------------|----------------|-----------|----------------|-----------------------------|---------------|---------------|
| NewBegun Creek | 7.6 | 3.7 | 21.7 | 11.6 | 901.7 | 741.7 | 1380.2 | 26.3 | 30.3 |
| Mill Dam Creek | 7.2 | 2.1 | 23.2 | 11.5 | 1087.5 | 773.8 | 1557.8 | 23.8 | 24.7 |
| Areneuse Creek | 7.4 | 3.4 | 24 | 12.3 | 1057.5 | 755 | 1514.5 | 26.1 | 32.1 |
| Pasquotank River | 6 | 2.6 | 9.2 | 5.3 | 110.6 | 77.6 | 165 | 26.9 | 28.4 |
| Sawyers Creek | 6.7 | 3.7 | 13.1 | 6.9 | 158.5 | 112.5 | 232.9 | 25.4 | 27.9 |
| Knobbs Creek | 6.9 | 4.7 | 14.6 | 7.9 | 271.7 | 199.4 | 408 | 26 | 27.8 |
| Pasquotank River2 | 7.4 | 7.2 | 24.9 | 11.4 | 1302.5 | 930 | 1869.6 | 27.3 | 30.2 |
| 2013 Water Source | | | | | | | | | |
| NewBegun Creek | 7.4 | 5 | 18 | 9.5 | 3242 | 2272.5 | 4890 | 27 | 29 |
| Mill Dam Creek | 7 | 2.5 | 24 | 10.5 | 3263.5 | 2331.5 | 4390 | 25.5 | 24.5 |
| Areneuse Creek | 7.4 | 2 | 22 | 11 | 2455 | 1751.5 | 3770 | 26 | 24.5 |
| Pasquotank River | 6.4 | 3 | 13 | 5.5 | 815.5 | 582.5 | 1070 | 26.5 | 30 |
| Sawyers Creek | 7.5 | 3.5 | 17.5 | 9.5 | 856 | 611 | 1090 | 28.5 | 33 |
| Knobbs Creek | 7.1 | 3 | 25.5 | 13 | 1314.5 | 910 | 2030 | 27 | 28.5 |
| 2011 Water Source | | | | | | | | | |
| NewBegun Creek | 5 | 4 | | 17 | 3006 | 2146 | 4000 | 27.5 | 29.7 |
| Mill Dam Creek | 5 | 4 | | 32 | 3203 | 2285 | 5000 | 27.8 | 27.6 |
| Areneuse Creek | 4 | 4 | | 19 | 2460 | 1758 | 4000 | 28.3 | 28.2 |
| Pasquotank River | 6 | 5 | | 14 | 761 | 541 | 1000 | 26.4 | 26 |
| Sawyers Creek | 7 | 4 | | 19 | 856 | 607 | 1000 | 25.9 | 26.3 |
| Knobbs Creek | 5 | 5 | | 23 | 1847 | 1325 | 3000 | 26.6 | 28.5 |

Figure 2. Averaged Water Source Readings for 2014, 2013, and 2011 Projects

B. Dissolved Oxygen

The dissolved oxygen measurements for 2014 corresponded to the 2013 and 2011 projects. The measurements differed between the head of the each waterway and their intersection with the Pasquotank River. The leading factor for calculating dissolved oxygen was wind and the width of the waterway. From the waterways that have been previously compared, Knobbs Creek had the best water quality this year, mainly due to its high dissolved oxygen readings. The lower Pasquotank River had a better reading than any other waterway this year, possibly due to its width and the winds affects.

C. TDS/Salinity/Conductivity

The 2014 readings for total dissolved solids (TDS), salinity, and conductivity have all decreased from the 2013

Watershed Research Project. Sawyers Creek's water quality fell between the two previous teams' WQIs with a medium water quality index. Knobbs Creek's water quality recorded a higher WQI than the two preceding teams and the highest for 2014. This year is the first year the lower Pasquotank has been tested. The lower Pasquotank had a good WQI due to it width.

| 2014 Water Source | 2014 WQI | 2013 WQI | 2011 WQI |
|-------------------|----------|----------|----------|
| NewBegun Creek | 59 | 66 | 50 |
| Mill Dam Creek | 49 | 47 | 48 |
| Areneuse Creek | 57 | 47 | 49 |
| Pasquotank River | 35 | 44 | 64 |
| Sawyers Creek | 51 | 50 | 54 |
| Knobbs Creek | 63 | 50 | 52 |
| Pasquotank River2 | 86 | | |

Figure 1. Water Quality Comparison between the 2014, 2013 and 2011 Projects

readings. The air temperature was lower in 2014 possibly illustrating a lower amount of evaporation which would yield a lower salinity reading. The lower salinity is, the lower the amount of ions in the water leading to lower conductivity readings.

Knobbs Creek had a high reading of salinity, TDS, and conductivity. This was possibly due to rain at the first set of test points. Rain decreases the salinity reading as it dilutes the salt. Newbegun Creek, Areneuse Creek, and the Pasquotank River had a high salinity reading as these brackish (high levels of salt) waterways are located nearer to the ocean. The TDS, salinity, and conductivity readings for the lower Pasquotank River were higher than any other waterway for this year's project.

Salinity in freshwater streams is a major indicator in sea level rise. This year's readings were much lower than previous years, which may have been due to more moderate temperatures during this year's research.

D. pH

The pH levels remained similar to the previous years' readings. Newbegun Creek, Mill Dam Creek, and Areneuse Creek had a base pH this year (7.1-14). The Pasquotank River, Sawyers Creek, and Knobbs Creeks had a reading of either 6.9 or lower which made them acidic. The lower Pasquotank River's pH readings were close to the other waterways this year.

E. Clarity/Turbidity

The clarity and turbidity readings have kept a constant standard from previous years. The clarity was always ten inches or higher than turbidity because turbidity determines the amount of suspended particles in the water and clarity determines how clear the water is. No variations were recognized. The lower Pasquotank River's readings were close to Mill Dam Creek, Areneuse Creek, and Newbegun Creek as these three waterways empty into the lower Pasquotank.

VI. CONCLUSION

A. Overall

In this year's project, the data and graphs present the continued healthiness of the Pasquotank Watershed. Determined by the Water Quality Index Calculator, this year's water quality has not greatly differed from 2013 and 2011 water quality tests.

B. Variations

There were minor variations found in the WQI, but the overall quality of the waterways this year was within the medium range or close to it. The most noticeable variation was the comparison between the 2014, 2013, and 2011 TDS, salinity, and conductivity readings. The readings for 2014 decreased greatly from the 2013 and 2011 readings. This may have been due to the lower temperatures during this year's research period.

C. The Lower Pasquotank River

This is the first year of testing the lower Pasquotank River. The water quality of this water was good compared to the other waterways. This was due to the width of the water waterway, its saltiness, and the close attachment to the ocean. The lower Pasquotank River is connected with Mill Dam Creek, Areneuse Creek, and Newbegun Creek. These waterways have similar pH, clarity, turbidity, dissolved oxygen, salinity, conductivity, and TDS readings.

D. Areneuse; Mill Dam; and Newbegun Creek

This year's readings continued to follow the pattern of last year's readings in that the salinity, TDS, and conductivity were much higher in the waterways below Elizabeth City where the Pasquotank River widens. With the addition of the four new waypoints in the lower Pasquotank, the team was able to gather data confirming this correlation. Continued testing of these new points will add to the further monitoring of this section of the watershed.

E. Data Sampling

The team was provided with sufficient tools to perform the field testing needed for each waterway. The test equipment allowed the team to gather two sets of data from each waterway. More data allows for more accuracy providing a more definite assessment of the Pasquotank watershed.

F. Data Presentation

The team used an online interactive map of data points created in 2011 and expanded in 2013. The code for this project utilized JavaScript and Hypertext Markup Language (HTML) to merge the spreadsheet information with the Google Maps interface.

Four points were added to the Pasquotank River, which is labeled as the lower Pasquotank Watershed for this project. These points are not as close together as the other waterways, but will allow for a larger area to be sampled.

VII. FUTURE WORKS

A. Boating/ Testing

For accurate testing, it is suggested that during the weekly boating trips on the LH Viking, tests be taken for points 28, 29, 30, and 31 of the lower Pasquotank River. This will increase the amount of data for these four points over a longer period of time.

B. Research Platform

The acquisition of a small outboard engine for the canoe, with costs between \$100 and \$1000, would decrease the time needed to test each waterway. This engine could be electric or gas with electric being the preferred due to stopping and starting conditions of testing each waterway.

C. Digital Thermometer

For a more accurate reading, a digital thermometer is suggested to be used in the field work. The Water-Proof Thermometer by Hoskin Scientific [28] has a probe cord of five feet and has retail price of \$32. This meter will provide a more accurate reading of the water temperature as compared to the current mercury thermometer being used.

D. Database Development

An online database that gives access to any set of data from any project year should be developed for future analysis. Developing a PHP Hypertext Preprocessor (PHP) interface with the data needed would allow for better comparison and contrasting of multiple sets of data.

E. Added Test

Adding the testing of nitrate or nitrogen would increase the accuracy of the Water Quality Index calculation. These, along with the other tests currently being performed, are major factors of determining the health of the water. The Hanna Instruments HI 764 Checker HC Handheld Colorimeter, For Nitrate, which is manufactured by Hanna Instruments, is a capable of measuring Nitrate. With this

meter, nitrate is measured in parts-per-billion (ppb). The retail price of this instrument is approximately \$47.30.

F. Inclement Weather Data Recording

During this year's trip, the inclement weather inhibited us to record data due to wet data sheets. This occurred on three trips. On the first trip, the data sheet was wet and difficult to read. The second trip, the equipment bags assisted in keeping the data sheet dry. The third trip, grease pens and laminated data sheets were used, but the data was not as readable. The "Rite in the Rain" company provides all-weather paper and writing utensils. It is recommended that the paper and pens be purchased from this company.

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